

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER

217219US0PCT

U.S. APPLICATION NO (IF KNOWN, SEE 37 CFR

10/018860

INTERNATIONAL APPLICATION NO.  
PCT/JP00/04250INTERNATIONAL FILING DATE  
28 June 2000PRIORITY DATE CLAIMED  
30 June 1999

## TITLE OF INVENTION

DIAMINOBENZENE DERIVATIVE, POLYIMIDE EMPLOYING IT, AND LIQUID CRYSTAL ALIGNMENT FILM

## APPLICANT(S) FOR DO/EO/US

HOSAKA Kazuyoshi et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1.  This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2.  This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3.  This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (24) indicated below.
4.  The US has been elected by the expiration of 19 months from the priority date (Article 31).
5.  A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a.  is attached hereto (required only if not communicated by the International Bureau).
  - b.  has been communicated by the International Bureau.
  - c.  is not required, as the application was filed in the United States Receiving Office (RO/US).
6.  An English language translation of the International Application as filed (35 U.S.C. 371(c)(2))
  - a.  is attached hereto.
  - b.  has been previously submitted under 35 U.S.C. 154(d)(4).
7.  Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a.  are attached hereto (required only if not communicated by the International Bureau).
  - b.  have been communicated by the International Bureau.
  - c.  have not been made, however, the time limit for making such amendments has NOT expired.
  - d.  have not been made and will not be made.
8.  An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9.  An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10.  An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).
11.  A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12.  A copy of the International Search Report (PCT/ISA/210).

## Items 13 to 20 below concern document(s) or information included:

13.  An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14.  An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15.  A **FIRST** preliminary amendment.
16.  A **SECOND** or **SUBSEQUENT** preliminary amendment.
17.  A substitute specification.
18.  A change of power of attorney and/or address letter.
19.  A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20.  A second copy of the published international application under 35 U.S.C. 154(d)(4)
21.  A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22.  Certificate of Mailing by Express Mail
23.  Other items or information:

PCT/IB/304/Form PTO-1449

PCT/IB/308

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR <b>10/018860</b>	INTERNATIONAL APPLICATION NO. <b>PCT/JP00/04250</b>	ATTORNEY'S DOCKET NUMBER <b>217219US0PCT</b>
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24. The following fees are submitted:

**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :**

<input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .....	\$1040.00
<input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO .....	\$890.00
<input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .....	\$740.00
<input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) .....	\$710.00
<input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) .....	\$100.00

**CALCULATIONS PTO USE ONLY**

**ENTER APPROPRIATE BASIC FEE AMOUNT =**

**\$890.00**

Surcharge of **\$130.00** for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)).

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	7 - 20 =	0	x \$18.00	<b>\$0.00</b>
Independent claims	3 - 3 =	0	x \$84.00	<b>\$0.00</b>
Multiple Dependent Claims (check if applicable).			<input type="checkbox"/>	<b>\$0.00</b>

**TOTAL OF ABOVE CALCULATIONS =**

**\$890.00**

Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.

**\$0.00**

**SUBTOTAL =**

**\$890.00**

Processing fee of **\$130.00** for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)).

Processing fee of <b>\$130.00</b> for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)).	<input type="checkbox"/> 20	<input type="checkbox"/> 30	+	<b>\$0.00</b>
<b>TOTAL NATIONAL FEE =</b>				<b>\$890.00</b>

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).	<input type="checkbox"/>	<b>\$0.00</b>
<b>TOTAL FEES ENCLOSED =</b>		<b>\$890.00</b>

<b>Amount to be:</b>	<b>\$</b>
<b>refunded</b>	
<b>charged</b>	<b>\$</b>

- A check in the amount of **\$890.00** to cover the above fees is enclosed.
- Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \_\_\_\_\_ to cover the above fees. A duplicate copy of this sheet is enclosed.
- The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.
- Fees are to be charged to a credit card. **WARNING: Information on this form may become public. Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:



**22850**

**Surinder Sachar  
Registration No. 34,423**

SIGNATURE

**Norman F. Oblon**

NAME

**24,618**

REGISTRATION NUMBER

*Dec. 26 2001*

DATE

DESCRIPTION

DIAMINOBENZENE DERIVATIVE, POLYIMIDE EMPLOYING IT, AND  
LIQUID CRYSTAL ALIGNMENT FILM

TECHNICAL FIELD

5 The present invention relates to a novel diaminobenzene derivative, a polyimide synthesized by using the compound as one of stating materials, and a liquid crystal alignment film containing the polyimide. More particularly, it relates to a diamine having a  
10 specific structure, which is industrially readily producible, a polyimide employing it, and a liquid crystal alignment film. The polyimide synthesized by using the diamine of the present invention, is particularly useful for an alignment film of a liquid  
15 crystal display device.

BACKGROUND ART

Heretofore, polyimides have been widely used as protecting materials or insulating materials in the electric and electronic fields, by virtue of high  
20 mechanical strength, heat resistance and solvent resistance, as their characteristics. However, developments in the electric and electronic fields in recent years have been remarkable, and increasingly high properties have been required also for materials to be  
25 used. Especially in the application to alignment films for liquid crystal display devices, polyimides have been mainly employed because of the uniformity and durability

of the coating film surface. However, in an attempt for high densification and high performance of liquid crystal displays, the surface properties of polyimide coating films have become important, and it has become necessary 5 to impart a new property which conventional polyimides do not have.

A liquid crystal display device is a display device utilizing an electro-optical change of liquid crystal and has undergone a remarkable development as a display 10 device for various displays in recent years in view of the characteristics such that it is small in size and light in weight as a device and its power consumption is small. Especially, a twisted nematic type (TN-type) electric field effect liquid crystal display device is a 15 typical example, wherein nematic liquid crystal having positive dielectric anisotropy is employed so that liquid crystal molecules are aligned in parallel with a substrate at the interface of each of a pair of mutually opposing electrode substrates, and the two substrates are 20 combined so that the directions for alignment of liquid crystal molecules are orthogonal to each other.

In such a TN-type liquid crystal display device, it is important that long axis directions of liquid crystal molecules are aligned uniformly in parallel with the 25 substrate surface and further that the liquid crystal molecules are aligned with a certain inclined alignment angle (hereinafter referred to as a tilt angle) against

the substrate. As typical methods for aligning liquid crystal molecules in such a manner, two methods have been known heretofore.

The first method is a method which comprises vapor 5 depositing an inorganic substance such as silicon oxide from an oblique direction to a substrate to form an inorganic film on the substrate, so that the liquid crystal molecules are aligned in the direction of vapor deposition. This method is not industrially efficient, 10 although uniform alignment with a constant tilt angle can be obtained.

The second method is a method which comprises forming an organic coating film on a substrate surface, and rubbing its surface in a predetermined direction with a 15 cloth of e.g. cotton, nylon or polyester, so that liquid crystal molecules are aligned in the rubbing direction. By this method, constant alignment can be obtained relatively easily, and industrially, this method is primarily employed. As the organic film, polyvinyl 20 alcohol, polyoxyethylene, polyamide or polyimide may, for example, be mentioned. However, from the viewpoint of the chemical stability, thermal stability, etc., polyimide is most commonly employed.

In the field of liquid crystal alignment films, it 25 has been difficult to obtain a high tilt angle constantly by the method of rubbing an organic film such as polyimide. As a means to solve such difficulty, JP-A-62-

297819 proposes a treating agent for liquid crystal alignment made of a mixture of a long chain alkyl compound with a polyimide precursor. Further, JP-A-64-25126 discloses a treating agent for liquid crystal alignment made of a polyimide using, as a starting material, a diamine having an alkyl group. Thus, many attempts have been made to increase the tilt angle of liquid crystal by introducing an alkyl group into polyimide, and it has been made possible to increase the tilt angle.

In recent years, there have been remarkable developments in the TN display device, and many new properties are now required also for a liquid crystal alignment film. Among them, it has been increasingly important to satisfy stabilization of the tilt angle and improvement in the uniformity of alignment simultaneously, from the viewpoint of improvement of the essential properties of the liquid crystal alignment film. As is evident also from JP-A-64-25126, an alkyl diamine which has been heretofore been known and mainly used, is characterized in that an alkyl group is connected to a phenylene diamine structure. However, if a conventional alkyl group-containing diamine is employed, there has been a problem that when a polyimide is to be synthesized, the alkyl group acts as a steric hindrance, whereby the reactivity tends to be low, and it takes time for polymerization, or in some cases,

polymerization does not proceed substantially. Taking time for the polymerization is problematic from the viewpoint of the industrial production, and the low polymerization reactivity is problematic from the

5 viewpoint of the durability as an alignment film of polyimide. Further, when copolymerization with another diamine is carried out, such a low reactivity brings about a difference in the reaction rate. The resulting polyimide is not necessarily uniform from the viewpoint 10 of the uniformity of the repeating units. Consequently, when it is made into a liquid crystal alignment film, even if a desired tilt angle may be obtained, the film has not necessarily been satisfactory from the viewpoint 15 of the uniformity of liquid crystal alignment.

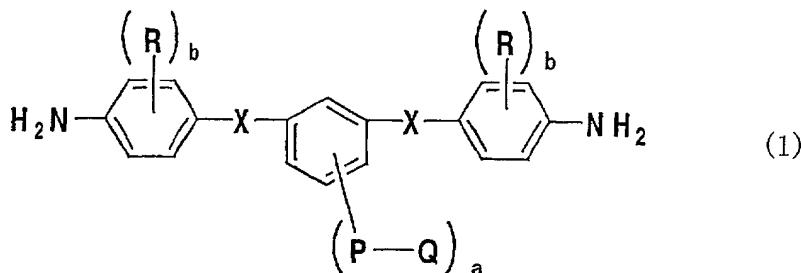
These problems are extremely important subjects to be solved to further improve the properties of a high quality, high precision liquid crystal display device represented by a future TN device. Namely, it has been desired to develop an alkyl diamine having an excellent 20 reactivity, a polyimide containing it as a constituting element and a polyimide liquid crystal orientation film, which contribute to the solution of such problems.

#### DISCLOSURE OF THE INVENTION

The present invention has been made under the above 25 circumstances. The present inventors have conducted extensive studies in detail and systematically to accomplish the above object, and as a result, have

completed the present invention.

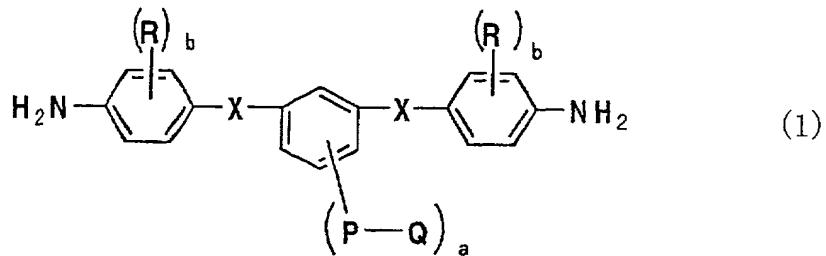
Namely, the present invention relates to a diaminobenzene derivative represented by the general formula (1) :



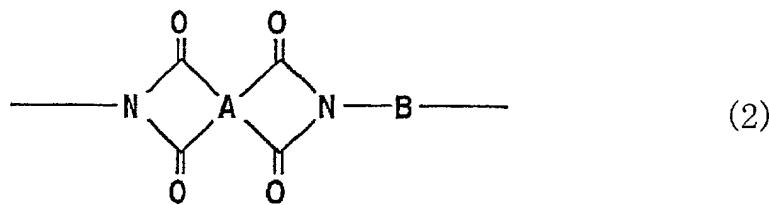
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(wherein each of X and P which are independent of each other, is a single bond or a bivalent organic group selected from -O-, -COO-, -OCO-, -CONH- and -NHCO-, Q is a C<sub>1-22</sub> straight chain alkyl group or straight chain 10 fluoroalkyl group, a is an integer of from 1 to 4 and represents the number of substituents, R is a substituent selected from fluorine, a methyl group and a trifluoromethyl group, and b is an integer of from 0 to 4 and represents the number of substituents).

15 Further, the present invention relates to a polyimide obtained by reacting a diamine containing at least 1 mol% of a diaminobenzene derivative represented by the general formula (1) :



(wherein each of X and P which are independent of each other, is a single bond or a bivalent organic group selected from  $-O-$ ,  $-COO-$ ,  $-OCO-$ ,  $-CONH-$  and  $-NHCO-$ , Q is 5 a  $C_{1-22}$  straight chain alkyl group or straight chain fluoroalkyl group, a is an integer of from 1 to 4 and represents the number of substituents, R is a substituent selected from fluorine, a methyl group and a trifluoromethyl group, and b is an integer of from 0 to 4 10 and represents the number of substituents), with at least one compound selected from a tetracarboxylic dianhydride and its derivatives, to obtain a polyimide precursor having a reduced viscosity of from 0.05 to 5.0  $dl/g$  (in  $N$ -methylpyrrolidone at a temperature of  $30^{\circ}C$ , 15 concentration: 0.5  $g/dl$ ) and ring-closing it, and having a repeating unit represented by the general formula (2):



20 (wherein A is a tetravalent organic group constituting a

tetracarboxylic acid, and B is a bivalent organic group constituting a diamine).

Still further, the present invention relates to a liquid crystal alignment film containing the above 5 polyimide.

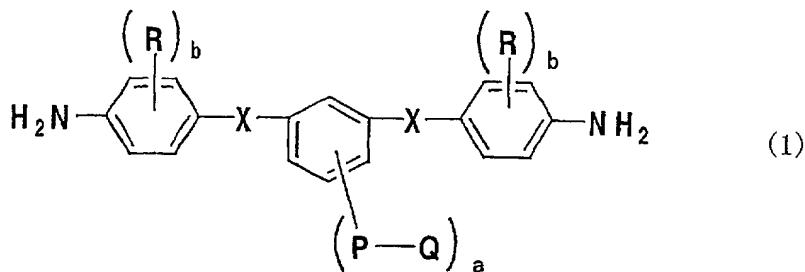
Now, the present invention will be described in detail.

The diaminobenzene derivative of the present invention can be easily synthesized and is useful as a 10 starting material for e.g. a polyimide or a polyamide. Further, this may be used as one of starting materials to obtain a polyimide having an alkyl group or a fluoroalkyl group as a side chain. This polyimide is useful for e.g. an insulating film for a semiconductor or a heat 15 resistant protective film for an optical device, but is particularly useful as an alignment film for a liquid crystal display device, and it has excellent characteristics such that not only polymerization is quick at the time of the preparation of a polyimide 20 precursor, but also a high tilt angle can easily be provided, and alignment of liquid crystal is good.

Particularly, the present invention has an important object to obtain a polyimide having a desired repeating unit quickly by using a specific diaminobenzene 25 derivative having an alkyl group and to realize uniformity of alignment and a high tilt angle imparted to liquid crystal, by using the specific polyimide

obtainable from the diamine, as a liquid crystal alignment film. For this purpose, Q in the general formula (1) is a C<sub>1-22</sub> straight chain alkyl group. This is essential to control the degree of the tilt angle, and such a group is connected to the polyimide main chain via a connecting portion P. Further, X is essential to connect a p-aminophenyl group. Further, R is necessary to control the surface property of the polyimide within a range not to impair the nucleophilic nature of an amino group, when a polymerization reactivity with a tetracarboxylic dianhydride and its derivative is taken into consideration.

The diaminobenzene derivative represented by the general formula (1):

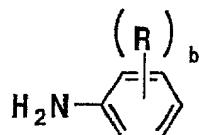


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(wherein each of X and P which are independent of each other, is a single bond or a bivalent organic group selected from -O-, -COO-, -OCO-, -CONH- and -NHCO-, Q is a C<sub>1-22</sub> straight chain alkyl group or straight chain fluoroalkyl group, a is an integer of from 1 to 4 and represents the number of substituents, R is a substituent selected from fluorine, a methyl group and a

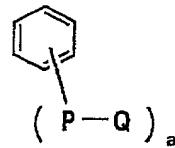
trifluoromethyl group, and  $b$  is an integer of from 0 to 4 and represents the number of substituents), is a diamine having a specific structure, and it comprises the following two amine portions:

5



(wherein  $R$  and  $b$  are the same as in the formula (1)), a connecting portion  $X$  and the following alkyl or fluoroalkylbenzene portion:

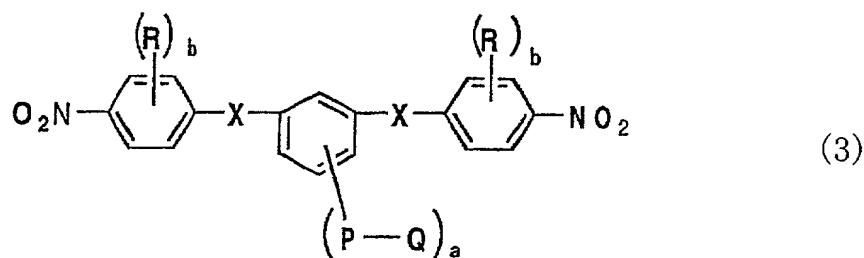
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(wherein  $P$ ,  $Q$  and  $a$  are the same as in the formula (1)). Its synthetic method is not particularly limited. For example, it can be synthesized by the following method.

Namely, in a synthesis of a diamine, it is common to 20 synthesize the corresponding dinitro compound represented by the general formula (3):

25



(wherein X, P, Q, a and b are the same as in the formula (1)), and to reduce the nitro groups by a usual method to convert them into amino groups.

Here, each of a and b which are independent of each other, represents the number of substituents; a is selected from integers of from 1 to 4 but is preferably 1 or 2 from the viewpoint of the surface property; and b is likewise selected from integers of from 0 to 2.

Each of connecting portions X and P which are independent of each other, is a connecting group such as a single bond, an ether bond -O-, an ester bond -COO-, a reverse ester bond -OCO-, an amide bond -CONH- or a reverse amide bond -NHCO-. From the viewpoint of the polymerization reactivity, an ether bond, an ester bond or an amide bond is particularly preferred.

Such a connecting group can be formed by a usual organic synthetic method. For example, in the case of an ether bond, it is common to react the corresponding halogen derivative and hydroxyl group-substituted derivative in the presence of an alkali, and in the case of an amide bond, it is common to react the corresponding acid chloride and amino group-substituted derivative in the presence of an alkali. Further, for the single bond, various methods are available, and common organic synthetic methods such as a Grignard reaction, a Friedel-Crafts acylation method of an aromatic ring, a Kishner reduction method and a cross coupling method, may be

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employed to suitably carry out the connection.

A specific example of the material for forming the dinitro moiety, is a benzene containing substituent Q and connecting group P, di-substituted by substituents for 5 forming the connecting portions X such as halogen atoms, hydroxyl groups, amino groups, carboxyl groups, halogenated acyl groups or carbonyl groups, and such a benzene is connected to a substituted p-nitro benzene derivative to obtain a desired dinitro compound.

10 Specific examples of the di-substituted benzene derivative include 3,5-dihydroxybenzoic acid, 3,5-dihydroxybenzoic acid chloride, 3,5-dicarboxyphenol, 3,5-diaminobenzoic acid and 3,5-diaminophenol. Further, the p-nitrobenzene derivative may, for example, be p-  
15 nitrofluorobenzene, p-nitrochlorobenzene, p-nitrobromobenzene, p-nitroiodobenzene, p-nitrophenol, p-nitrobenzoic acid, p-nitrobenzoic acid chloride, 2-methyl-4-nitrophenol, 2-trifluoromethyl-4-nitrophenol, 2-methyl-4-nitrobenzoic acid, 2-methyl-4-nitrobenzoic acid  
20 chloride, 2-trifluoromethyl-4-nitrobenzoic acid, 2-trifluoromethyl-4-nitrobenzoic acid chloride or acetanilide. A combination thereof may be suitably selected depending upon the particular purpose taking into consideration the reactivity and the availability of  
25 the materials. It should be mentioned that those exemplified here are only examples.

The chain substituent Q in the general formula (1)

is a C<sub>1-22</sub> straight chain alkyl group or straight chain fluoroalkyl group. The carbon number can be suitably selected in order to obtain the desired tilt angle when the corresponding polyimide is used as an alignment film.

5        The diaminobenzene derivative of the present invention represented by the above general formula (1) obtainable by the method as described above, may be subjected to polycondensation with a tetracarboxylic acid dianhydride and its derivative, such as tetracarboxylic 10 dianhydride, a tetracarboxylic dihalide or tetracarboxylic acid, to synthesize a polyimide having a specific structure at its side chain.

      The method for obtaining the polyimide of the present invention, is not particularly limited.

15      Specifically, it can be obtained by reacting and polymerizing the above diamine with at least one compound selected from a tetracarboxylic dianhydride and its derivatives, to obtain a polyimide precursor, followed by ring-closing imide conversion.

20      The tetracarboxylic dianhydride and its derivatives to be used to obtain the polyimide of the present invention, are not particularly limited.

      Specific examples thereof include aromatic tetracarboxylic dianhydrides such as pyromellitic 25 dianhydride, 2,3,6,7-naphthalene tetracarboxylic dianhydride, 1,2,5,6-naphthalene tetracarboxylic dianhydride, 2,3,6,7-anthracene tetracarboxylic

dianhydride, 1,2,5,6-anthracene tetracarboxylic  
dianhydride, 3,3',4,4'-biphenyl tetracarboxylic  
dianhydride, 2,3,3',4-biphenyl tetracarboxylic  
dianhydride, bis(3,4-dicarboxyphenyl)ether dianhydride,  
5 3,3',4,4'-benzophenone tetracarboxylic dianhydride,  
bis(3,4-dicarboxyphenyl)sulfone dianhydride, bis(3,4-  
dicarboxyphenyl)methane dianhydride, 2,2-bis(3,4-  
dicarboxyphenyl)propane dianhydride, 1,1,1,3,3,3-  
hexafloro-2,2-bis(3,4-dicarboxyphenyl)propane  
10 dianhydride, bis(3,4-dicarboxyphenyl)dimethyl silane  
dianhydride, bis(3,4-dicarboxyphenyl)diphenyl silane  
dianhydride, 2,3,4,5-pyridine tetracarboxylic  
dianhydride, and 2,6-bis(3,4-dicarboxyphenyl)pyridine  
dianhydride, and their tetracarboxylic acids and their  
15 dicarboxylic acid diacid halides; alicyclic  
tetracarboxylic dianhydrides such as 1,2,3,4-cyclobutane  
tetracarboxylic dianhydride, 1,2,3,4-cyclopentane  
tetracarboxylic dianhydride, 1,2,4,5-cyclohexane  
tetracarboxylic dianhydride, 2,3,5-tricarboxycyclopentyl  
20 acetic dianhydride, and 3,4-dicarboxy-1,2,3,4-tetrahydro-  
1-naphthalene succinic dianhydride, and their  
tetracarboxylic acids and their dicarboxylic acid diacid  
halides; and aliphatic tetracarboxylic dianhydrides such  
as 1,2,3,4-buthane tetracarboxylic dianhydride, and their  
25 tetracarboxylic acids and their dicarboxylic acid diacid  
halides.

Especially for application to alignment films,

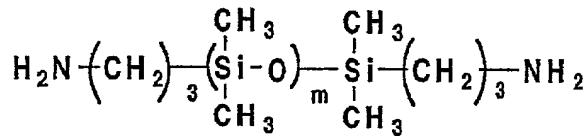
alicyclic tetracarboxylic dianhydrides, and their tetracarboxylic acids and their dicarboxylic acid diacid halides are preferred from the viewpoint of the transparency of the coating film. Particularly preferred are 1,2,3,4-cyclobutane tetracarboxylic dianhydride, 3,4-dicarboxy-1,2,3,4-tetrahydro-1-naphthalene succinic dianhydride, bicyclo[3.3.0]-octane-tetracarboxylic dianhydride and 3,5,6-tricarboxynorbornane-2:3,5:6 dianhydride. Further, one or more of these 10 tetracarboxylic dianhydrides and their derivatives may be used in admixture.

In the present invention, the tetracarboxylic dianhydride and its derivative may be copolymerized with the diaminobenzene derivative represented by the general 15 formula (1) (hereinafter referred to simply as the diamine(1)) and other common diamines (hereinafter referred to simply as common diamines).

The common diamines to be used here are primary diamines commonly used for the synthesis of polyimides, 20 and they are not particularly limited. Specific examples thereof include aromatic diamines such as p-phenylenediamine, m-phenylenediamine, 2,5-diaminotoluene, 2,6-diaminotoluene, 4,4'-diaminobiphenyl, 3,3'-dimethyl-4,4'-diaminobiphenyl, 3,3'-dimethoxy-4,4'-diaminobiphenyl, 25 diaminodiphenylmethane, diaminodiphenyl ether, 2,2'-diaminodiphenylpropane, bis(3,5-diethyl-4-aminophenyl)methane, diaminodiphenylsulfone,

diaminobenzophenone, diaminonaphthalene, 1,4-bis(4-aminophenoxy)benzene, 1,4-bis(4-aminophenyl)benzene, 9,10-bis(4-aminophenyl)anthracene, 1,3-bis(4-aminophenoxy)benzene, 4,4'-bis(4-aminophenoxy)diphenylsulfone, 2,2-bis[4-(4-aminophenoxy)phenyl]propane, 2,2-bis(4-aminophenyl)hexafluoropropane and 2,2-bis[4-(4-aminophenoxy)phenyl]hexafluoropropane; aliphatic diamines such as bis(4-aminocyclohexyl)methane and bis(4-amino-3-methylcyclohexyl)methane, and aliphatic diamines such as tetramethylenediamine and hexamethylenediamine; as well as diaminocyclooxanes such as

15



(wherein  $m$  is an integer of from 1 to 10). Further, these diamines may be used alone or in combination as a mixture of two or more of them.

20 By adjusting the proportion of the molar amount of the diamine (1) in the total molar amount of diamines used at the time of polymerization of the polyimide of the present invention, the surface property of the polyimide such as water repellency can be modified, and 25 further in a case where it is used as a liquid crystal alignment film, wettability with liquid crystal, and further, the tilt angle of liquid crystal, can be

increased. The proportion of the molar amount of the diamine (1) in the total molar amount of diamines to be used here, is at least 1 mol%.

Further, when it is used as a liquid crystal alignment film, it is common to adjust the proportion of the molar amount of the diamine (1) in the total molar amount of diamines to be used, to be within a range of from 1 mol% to 100 mol% from such a viewpoint that a polyimide having a practically suitable degree of polymerization can easily be obtained, or that the tilt angle required in a common liquid crystal display system (such as a twisted nematic system) is usually at a level of from a few degrees to about 10 degrees in many cases, although it may depend also on the number of alkyl of Q.

Further, in the case of a perpendicular alignment system, the molar amount of the diamine (1) is usually from 40 mol% to 100 mol%.

The tetracarboxylic dianhydride and its derivative, and the above mentioned diamine, are reacted and polymerized to obtain a polyimide precursor, and then this is converted to an imide by ring closure. As the tetracarboxylic dianhydride and its derivative to be used here, it is common to employ tetracarboxylic dianhydride. The ratio of the molar amount of the tetracarboxylic dianhydride to the total molar amount of the diamine (1) and common diamines, is preferably from 0.8 to 1.2. Like in a usual polycondensation reaction, the polymerization

degree of the resulting polymer tends to be large, as the molar ratio becomes close to 1.

If the polymerization degree is too small, the strength of the polyimide film tends to be inadequate.

5 On the other hand, if the polymerization degree is too large, the operation efficiency at the time of formation of the polyimide film tends to be poor in some cases. Accordingly, the polymerization degree of the product in this reaction is preferably from 0.05 to 5.0 dl/g (in N-  
10 methylpyrrolidone at a temperature of 30°C, concentration: 0.5g/dl) as calculated as the reduced viscosity of the polyimide precursor solution.

A method for reacting and polymerizing the carboxylic dianhydride and the above diamine, is not particularly  
15 limited. It is common to employ a method wherein the above diamine is dissolved in an organic polar solvent such as N-methylpyrrolidone, N,N-dimethylacetamide or N,N-dimethylformamide, and to the solution, the tetracarboxylic dianhydride is added and reacted to  
20 synthesize a polyimide precursor, followed by dehydration ring closure for conversion to an imide.

The reaction temperature at the time of the reacting the tetracarboxylic dianhydride and the above mentioned diamine to obtain a polyimide precursor, may be an  
25 optional temperature selected within a range of from -20 to 150°C, preferably from -5 to 100°C. Further, this polyimide precursor is subjected to dehydration under

heating at a temperature of from 100 to 400°C, or subjected to chemical imide-conversion by means of an imide-conversion catalyst such as pyridine/acetic anhydride, which is commonly used, to obtain a polyimide.

5 In such a case, the imide conversion can be controlled optionally within a range of from 0 to 100% by reaction conditions. In an application to an alignment film, the imide conversion is preferably from 60 to 100%.

When the polyimide of the present invention is to be 10 used as an insulating film or a protecting film for an electric or electronic element, or as an alignment film for a liquid crystal display device, it is necessary to form a polyimide coating film having a uniform film thickness on a substrate.

15 To form this polyimide coating film, it is usually possible to form a polyimide coating film by coating the polyimide precursor solution by itself on a substrate and heating it for imide-conversion on the substrate. The polyimide precursor solution to be used here may be the 20 above polymer solution by itself, or the formed polyimide precursor may be put into a large excess amount of a poor solvent such as water or methanol to precipitate and recover it, and then it may be used as re-dissolved in a solvent. The solvent for diluting the above polyimide 25 precursor solution and/or the solvent for re-dissolving the precipitated and recovered polyimide precursor, is not particularly limited so long as it is capable of

dissolving the polyimide precursor.

Specific examples of such solvents include N-methylpyrrolidone, N,N-dimethylacetamide, and N,N-dimethylformamide. These solvents may be used alone or 5 as mixed. Further, even in the case of a solvent which is incapable of presenting a uniform solution by itself, such a solvent may be added and used within a range where a uniform solution can be obtained. As such an example, ethyl cellosolve, butyl cellosolve, ethyl carbitol, butyl 10 carbitol, ethyl carbitol acetate or ethylene glycol may be mentioned. Further, for the purpose of improving the adhesion of the polyimide film to the substrate, it is of course preferred to add an additive such as a coupling agent to the obtained polyimide precursor solution.

15 Further, an optional temperature within a range of from 100 to 400°C may be employed as the temperature for heating for imide-conversion on the substrate. However, particularly preferred is within a range of from 150 to 350°C.

20 On the other hand, in a case where the polyimide of the present invention is soluble in a solvent, the polyimide precursor obtained by the reaction of the tetracarboxylic dianhydride and the above mentioned diamine, may be imide-converted in the solvent to obtain 25 a polyimide solution. To convert the polyimide precursor to a polyimide in the solution, it is common to employ a method wherein dehydration ring-closure is carried out by

heating. This ring closure temperature by dehydration under heating may be an optional temperature selected within a range of from 150 to 350°C, preferably from 120 to 250°C. As another method for converting the polyimide 5 precursor to the polyimide, it is possible to carry out ring closure chemically by means of a known dehydration ring-closing catalyst.

The polyimide solution thus obtained, may be used by itself, or may be precipitated and isolated in a poor 10 solvent such as methanol or ethanol, and then it may be used as re-dissolved in a proper solvent. The solvent for re-dissolution is not particularly limited so long as it is capable of dissolving the polyimide, but as an example, 2-pyrorridone, N-methyl pyrrolidone, N-ethyl pyrrolidone, N-vinyl pyrrolidone, N, N-dimethyl acetoamide, N,N-dimethylformamide or  $\gamma$ -butyrolactone may 15 be mentioned.

Further, even a solvent which is incapable of dissolving this polyimide by itself, may be added to the 20 above solvent within a range not to impair the solubility. As such an example, ethyl cellosolve, butyl cellosolve, ethyl carbitol, butyl carbitol, ethyl carbitol acetate or ethylene glycol may be mentioned.

Further, for the purpose of further improving the 25 adhesion of the polyimide film to the substrate, it is of course preferred to add an additive such as a coupling agent to the obtained polyimide solution.

This solution is coated on a substrate, and the solvent is evaporated, whereby a polyimide coating film can be formed on the substrate. The temperature at that time may be sufficient so long as the solvent can be 5 evaporated, and usually a temperature of from 80 to 150°C is sufficient.

Further, when it is used as a liquid crystal alignment film, a polyimide film having a film thickness of from 100 to 3000Å, is formed on a transparent 10 substrate of e.g. glass or plastic film provided with transparent electrodes, and then, the polyimide film is subjected to rubbing treatment to obtain a liquid crystal alignment film.

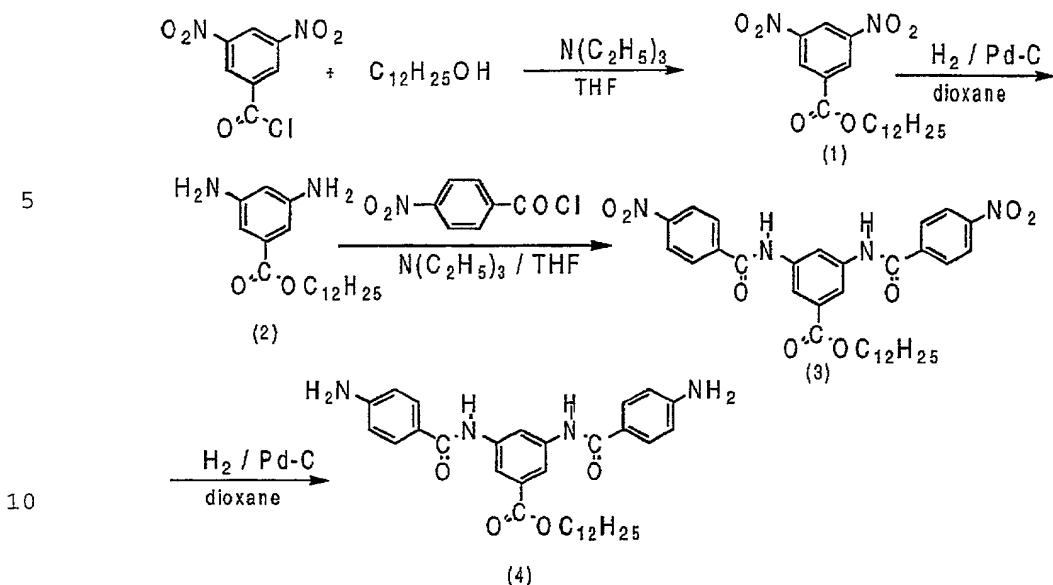
BEST MODE FOR CARRYING OUT THE INVENTION

15 Now, the present invention will be described in further detail with reference to Examples, but the present invention is by no means restricted to such Examples.

Syntheses of diamines

20 EXAMPLE 1

(Synthesis of n-dodecyl[3,5-bis(4-aminobenzoylamino)]benzoate) (4)



10013660 "J2000"

15 Into a 500 ml flask, 1-dodecanol (65.01g, 348.9 mmol), triethylamine (44.00g, 435.0 mmol) and tetrahydrofuran (410 ml) were added to obtain a uniform solution, and then, a THF solution (80 ml) of 3,5-benzoyl chloride (80.16g, 347.7 mmol) was dropwise added. Thereafter, refluxing and stirring were continued for 2.5 hours. The reaction solution was poured into water, and the precipitated solid was separated by filtration and re-crystallized from acetonitrile to obtain colorless crystals (121.12g, yield: 82%). From the IR and NMR spectra, the crystals were confirmed to be n-dodecyl-3,5-dinitrobenzoate (1). Melting point: 64°C.

20 Dioxane (250 ml) was added to n-dodecyl-3,5-dinitrobenzoate (1) (25.13g, 59.2 mmol), and to this solution, Pd-C (1.51g) was added in a nitrogen

atmosphere, followed by stirring for 7 hours in a hydrogen atmosphere. Pd-C was filtered off, and the filtrate was poured into water, and the precipitated crystals were corrected by filtration. After drying,  
5 they were re-crystallized from n-hexane to obtain slightly yellow crystals (18.46g, yield: 79%). From the IR and NMR spectra, the crystals were confirmed to be n-dodecyl-3,5-diaminobenzoate (2). Melting point 64°C.

10 Into a 200 ml flask, n-dodecyl-3,5-diaminobenzoate (2) (8.01g, 20.3 mmol), triethylamine (4.57g, 45.2 mmol), and tetrahydrofuran (100 ml) were added to obtain a uniform solution, and then, a THF solution (50 ml) of 4-nitrobenzoyl chloride (7.93g, 42.8 mmol) was dropwise added. Thereafter, refluxing and stirring were continued  
15 for 6 hours. The reaction solution was poured into water, and the precipitated solid was collected by filtration and recrystallized from acetonitrile to obtain slightly yellow crystals (10.15g, yield: 81%). From the IR and NMR spectra, the crystals were found to be n-dodecyl[3,5-bis(4-nitrobenzoylamino)]benzoate (3).  
20 Melting point: 189°C.

25 Dioxane (160 ml) was added to n-dodecyl[3,5-bis(4-nitrobenzoylamino)]benzoate (3) (7.99g, 12.9 mmol), and to this solution, Pd-C (0.87g) was added in a nitrogen atmosphere, followed by stirring for 4 hours in a hydrogen atmosphere. Pd-C was filtered off, and then, the filtrate was poured into water, and the precipitated

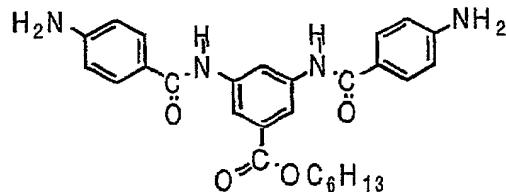
crystals were collected by filtration. After drying, they were recrystallized from THF-n-hexane to obtain slight yellow crystals (4.25g, yield: 65%). From the IR and NMR spectra, these crystals were found to be the 5 desired n-dodecyl[3,5-bis(4-aminobenzoylamino)]benzoate (4) (melting point: 186°C).

The analytical results are shown below.

<sup>1</sup>H-NMR (d-DMSO, δ ppm) : 9.9(2H, s), 8.6(1H, s), 8.1(2H, s), 7.8(4H, d), 6.6(4H, d), 5.8(4H, s), 4.3(2H, t), 1.7(2H, m), 1.2-1.4(18H, broad), 0.8(3H, t).  
10 IR (KBr, cm<sup>-1</sup>) : 3445, 3387, 3351(NH<sub>2</sub>), 3304, 3200(NH), 2955, 2922, 2853(CH<sub>2</sub>), 1710(COO), 1640, 1608(CONH).

#### EXAMPLE 2

15 (Synthesis of n-hexyl[3,5-bis(4-aminobenzoylamino)]benzoate)



20 (5)

Using 3,5-dinitrobenzoyl chloride (74.3g, 322.5 mmol) and hexyl alcohol (33.0g, 323.6 mmol), n-hexyl-3,5-dinitrobenzoate was obtained (81.1g, yield: 85%) in the 25 same manner as in Example 1.

Using the obtained dinitro compound (33.4g, 112.8 mmol), reduction was carried out in the same manner as in

Example 1, followed by recrystallization to obtain n-hexyl-3,5-diaminobenzoate (25.6g, yield: 96%).

Using n-hexyl-3,5-diaminobenzoate (24.0g, 101.7 mmol) and 4-nitrobenzoyl chloride (39.7g, 214.4 mmol), n-hexyl[3,5-bis(4-nitrobenzoylamino)]benzoate was obtained (44.5g, yield: 82%) in the same manner as in Example 1.

Finally, this dinitro compound (20.4g, 38.2 mmol) was reduced in the same manner as in Example 1, followed by recrystallization to obtain n-hexyl[3,5-bis(4-aminobenzoylamino)] (5) was obtained (14.8g, yield: 82%).

Melting point: 208°C. The analytical results are shown below.

Mass (m/e) : 474 (M+).

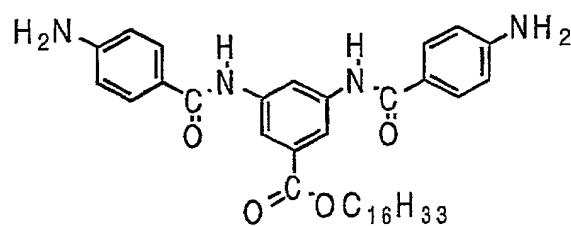
<sup>1</sup>H-NMR (d-DMSO, δ ppm) : 9.9 (2H, s), 8.6 (1H, s), 8.1 (2H, s), 7.8 (4H, d), 6.6 (4H, d), 5.8 (4H, s), 4.3 (2H, t), 1.7 (2H, m), 1.2-1.4 (6H, broad), 0.9 (3H, t).

IR (KBr, cm<sup>-1</sup>) : 3445, 3339, 3351 (NH<sub>2</sub>), 3304, 3204 (NH), 2955, 2931 (CH<sub>2</sub>), 1694 (COO), 1645, 1605 (CONH).

### EXAMPLE 3

(Synthesis of n-hexadecyl[3,5-bis(4-aminobenzoylamino)]benzoate (6))

25



(6)

Using 3,5-dinitrobenzoyl chloride (60.6g, 263.0 mmol) and hexadecyl alcohol (63.9g, 263.9 mmol), n-hexadecyl-3,5-dinitrobenzoate was obtained (103.2g, yield: 90%) in the same manner as in Example 1.

5       Using the obtained dinitro compound (40.68g, 93.3 mmol), reduction was carried out in the same manner as in Example 1, followed by recrystallization to obtain n-hexadecyl-3,5-diaminobenzoate (35.0g, yield: 100%).

10      Using the diamine compound (16.7g, 44.4 mmol) and 4-nitrobenzoyl chloride (17.3g, 93.6 mmol), n-hexadecyl[3,5-bis(4-nitrobenzoylamino)]benzoate was obtained (25.4g, yield: 85%) in the same manner as in Example 1.

15      Finally, this dinitro compound (13.4g, 19.9 mmol) was reduced in the same manner as in Example 1, followed by recrystallization to obtain n-hexadecyl[3,5-bis(4-aminobenzoylamino)] (6) was obtained (12.0g, yield: 98%). Melting point: 139°C. The analytical results are shown below.

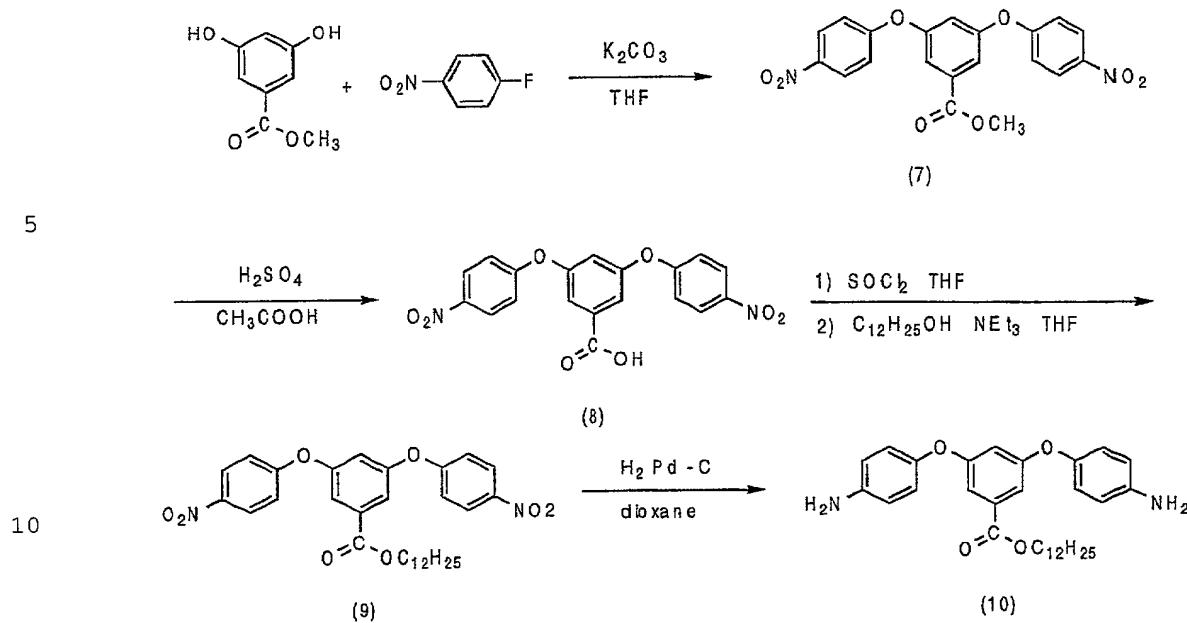
20      Mass (m/e) : 614 (M+).

<sup>1</sup>H-NMR (d-DMSO, δ ppm) : 10.0(2H, s), 8.6(1H, s), 8.1(2H, s), 7.8(4H, d), 6.6(4H, d), 5.8(4H, s), 4.3(2H, t), 1.7(2H, m), 1.2-1.4(26H, broad), 0.8(3H, t).

IR (KBr, cm<sup>-1</sup>) : 3388, 3346(NH<sub>2</sub>), 3304, 3204(NH), 2952, 2917, 2834(CH<sub>2</sub>), 1708(COO), 1645, 1609(CONH).

25      EXAMPLE 4

(Synthesis of n-dodecyl[3,5-bis(4-aminophenoxy)]benzoate)  
(10))



Into a 500 ml flask, 3,5-dihydroxymethyl benzoate (40.0g, 238.1 mmol) obtained by a usual method, 4-fluoronitrobenzene (67.1g, 475.8 mmol), potassium carbonate (65.4g) and dimethylacetamide (350 ml) were added, followed by stirring at 95°C for 9 hours. The reaction solution was subjected to filtration, and the filtrate was left to stand for one day. The precipitated solid was collected by filtration and recrystallized from ethyl acetate to obtain colorless solid 3,5-bis(4-nitrophenoxy)methyl benzoate (7) (78.5g, yield: 80%).  
 Melting point: 183°C.

Into a 1l flask, the above dinitro compound (70.0g, 170.7 mmol), sulfuric acid (17.5g) and acetic acid (600 ml) were put, followed by refluxing and stirring for 8 hours. The reaction solution was left to stand for one

day, and the precipitated solid was collected by filtration. Recrystallization from acetic acid was carried out to obtain 3,5-bis(4-nitrophenoxy) benzoate (8) as colorless crystals (59.3g, yield: 87%). Melting point: 230°C.

5      Into a 500 ml flask, 3,5-bis(4-nitrophenoxy) benzoate (8) (45.0g, 114.0 mmol) and thionyl chloride (250 ml) were put, and refluxed and stirred for 3 hours. After completion of the reaction, excess thionyl chloride was 10     removed by distillation, and THF (400 ml) was added to the residue. This THF solution was dropwise added at 80°C to a THF solution (100 ml) of n-dodecyl alcohol (23.5g, 126.3 mmol) and triethylamine (12.7g, 125.7 mmol). After completion of the dropwise addition, 15     refluxing and stirring were carried out for 15 hours. The solution was concentrated and poured into water (1500 ml) and extracted with ethyl acetate. The organic layer was washed with water and 1N sodium hydroxide and dried over anhydrous sodium sulfate. Further, the solvent was 20     distilled off under reduced pressure, and the residue was recrystallized from acetonitrile to obtain n-dodecyl[3,5-bis(4-nitrophenoxy)]benzoate (9) (47.6g, yield: 74%). Melting point: 64°C.

25      Dioxane (300 ml) was added to n-dodecyl[3,5-bis(4-nitrophenoxy)]benzoate (9) (15.7g, 27.8 mmol), and to this solution, Pd-C (1.7g) was added in a nitrogen atmosphere, followed by stirring for 6 hours in a

hydrogen atmosphere. Pd-C was filtered off, and the filtrate was poured into water, and the precipitated crystals were collected by filtration. After drying, they were recrystallized from acetonitrile to obtain 5 slight yellow crystals (9.00g, yield: 65%). Melting point: 49°C. From the IR, NMR and Mass spectra, the crystals were found to be the desired n-dodecyl[3,5-bis(4-aminobenzoylamino)]benzoate (10). The analytical results are shown below.

10

Mass (m/e) : 504 (M+).

<sup>1</sup>H-NMR (d-DMSO, δ ppm) : 7.2(2H, s), 6.9(4H, d), 6.7(1H, s), 6.6(4H, d), 4.2(2H, t), 3.8(4H, s), 1.6(2H, m), 1.1-1.3(18H, broad), 0.9(3H, t).

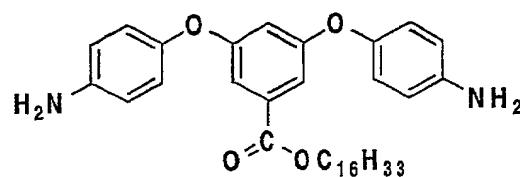
IR (KBr, cm<sup>-1</sup>) : 3459, 3374(NH<sub>2</sub>), 3304, 3200(NH), 2959, 2917, 2847(CH<sub>2</sub>), 1708(COO), 1216(ArO).

15

#### EXAMPLE 5

(Synthesis of n-hexadecyl[3,5-bis(4-aminobenzoylamino)]benzoate (11))

20



(11)

25

Using 3,5-bis(4-nitrophenoxy)benzoate (8) (25.6g, 64.6 mmol) obtained in Example 4 and n-hexadecyl alcohol (17.3g, 71.5 mmol), n-hexadecyl[3,5-bis(4-

nitrophenoxy) ]benzoate was obtained (32.4g, yield: 81%) in the same manner as in Example 4.

Finally, this dinitro compound (16.4g, 26.5 mmol) was reduced in the same manner as in Example 4, followed 5 by recrystallization to obtain n-hexadecyl[3,5-bis(4-aminophenoxy) ]benzoate (11) (13.5g, yield: 91%). The melting point: 54°C. The analytical results are shown below.

10 Mass (m/e) : 560 (M+).  
1H-NMR (d-DMSO, δ ppm) : 7.2(2H, s), 6.8(4H, d), 6.6(1H, s), 6.5(4H, d), 4.2(2H, t), 3.8(4H, s), 1.6(2H, m), 1.1-1.4(26H, broad), 0.9(3H, t).  
IR (KBr, cm⁻¹) : 3460, 3376(NH₂), 3302, 3200(NH), 2960, 2917, 2847(CH₂), 1708(COO), 1216(ArO).

15 EXAMPLE 6

(Preparation of a polyimide)

5g (10.5 mmol) of n-dodecyl[3,5-bis(4-aminobenzoylamino) ]benzoate obtained in Example 1 and 2.1g (10.5g) of 1,2,3,4-cyclobutanetetracarboxylic 20 dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at 20°C for 8 hours to carry out a polycondensation reaction to obtain a polyimide precursor solution.

The reduced viscosity of the obtained polyimide 25 precursor was 0.80 dL/g (at a concentration of 0.5 g/dL in N-methylpyrrolidone at 30°C).

This solution was heat-treated at 180°C for one hour

to obtain a uniform polyimide coating film. The obtained coating film was subjected to IR measurement and was confirmed to be a polyimide having a dodecyl group.

EXAMPLE 7

5        5g (10.5 mmol) of n-dodecyl[3,5-bis(4-aminobenzoylamino)]benzoate obtained in Example 1 and 2.6g (10.5 mmol) of bicyclo[3,3,0]-octane-tetracarboxylic dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at 20°C for 8 hours to carry out a 10 polycondensation reaction to obtain a polyimide precursor solution. The reduced viscosity of the obtained polyimide precursor was 0.70 dL/g (at a concentration of 0.5 g/dL in N-methylpyrrolidone at 30°C).

15        To this solution, acetic anhydride and pyrimidine were added as an imide conversion catalyst, followed by a reaction at 60°C for one hour to obtain a soluble polyimide resin solution. This solution was put into methanol, and the obtained precipitate was collected by filtration and dried to obtain a white polyimide powder.

20        This polyimide resin powder was confirmed to be 70% imide-converted, by NMR. Further, the obtained coating film was subjected to IR measurement and was confirmed to be a polyimide having a dodecyl group.

EXAMPLE 8

25        5g (10.5 mmol) of n-dodecyl[3,5-bis(4-aminobenzoylamino)]benzoate obtained in Example 1 and 2.9g (10.5 mmol) of 3,4-dicarboxy-1,2,3,4-tetrahydro-1-

naphthalene succinic dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at 20°C for 8 hours to carry out a polycondensation reaction to obtain a polyimide precursor solution. The reduced viscosity of 5 the obtained polyimide precursor was 0.75 dl/g (at a concentration of 0.5 g/dl in N-methylpyrrolidone at 30°C).

To this solution, acetic anhydride and pyrimidine were added as an imide-conversion catalyst, followed by a 10 reaction at 60°C for one hour to obtain a soluble polyimide resin solution. This solution was put into 500g of methanol, and the obtained precipitate was collected by filtration and dried to obtain a white polyimide powder.

15 This polyimide resin powder was confirmed to be 90% imide-converted, by NMR. Further, the obtained coating film was subjected to IR measurement and confirmed to be a polyimide having a dodecyl group.

#### EXAMPLE 9

20 5g (10.5 mmol) of n-dodecyl[3,5-bis(4-aminobenzoylamino)]benzoate obtained in Example 1 and 2.6g (10.5 mmol) of 3,5,6-tricarboxynorbornene-2:3,5:6 dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at 20°C for 8 hours to carry out a 25 polycondensation reaction to obtain a polyimide precursor solution. The reduced viscosity of the obtained polyimide precursor was 0.55 dl/g (at a concentration of

0.5 g/dl in N-methylpyrrolidone at 30°C).

To this solution, acetic anhydride and pyridine were added as an imide conversion catalyst, followed by a reaction at 60°C for one hour to obtain a soluble 5 polyimide resin solution. This solution was put into 500g of methanol, and the obtained precipitate was collected by filtration and dried to obtain a white polyimide powder.

This polyimide resin powder was confirmed to be 90% 10 imide-converted, by NMR. Further, the obtained coating film was subjected to IR measurement and confirmed to be a polyimide having a dodecyl group.

#### EXAMPLES 10 to 20

Using the diamines synthesized in Examples 2 to 5 15 and using tetracarboxylic dianhydrides employed in Examples 6 to 9, polyimides were synthesized in accordance with the respective Examples, and subjected to IR measurements in accordance with Example 6 and confirmed to be the desired polyimides. In the following 20 Table 1, the reduced viscosities of the precursor solutions of the polyimides (at a concentration of 0.5 g/dl in N-methylpyrrolidone at 30°C) will be given.

Table 1

Example No.	Diamine	Tetracarboxylic dianhydride	Reduced viscosity (dl/g)
10	Example 2	Example 6	1.05
11	Example 2	Example 7	0.82
12	Example 2	Example 8	0.77
13	Example 2	Example 9	0.60
14	Example 3	Example 6	0.74
15	Example 3	Example 7	0.75
16	Example 3	Example 8	0.65
17	Example 3	Example 9	0.53
18	Example 4	Example 6	1.14
19	Example 4	Example 7	0.96
20	Example 4	Example 8	0.88
21	Example 4	Example 9	0.67
22	Example 5	Example 6	1.03
23	Example 5	Example 7	0.89
24	Example 5	Example 8	0.83
25	Example 5	Example 9	0.60

## COMPARATIVE EXAMPLE 1

5g (14.3 mmol) of hexadecyloxy-2,4-diaminobenzene as a diamine and 2.8g (14.3 mmol) of 1,2,3,4-5 cyclobutanetetracarboxylic dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at 20°C for 8 hours to carry out a polycondensation reaction to obtain a polyimide precursor solution. The reduced

viscosity of the obtained polyimide precursor was as low as 0.35 dL/g (at a concentration of 0.5 g/dL in N-methylpyrrolidone at 30°C).

#### COMPARATIVE EXAMPLE 2

5 5g (14.3 mmol) of hexadecyloxy-2,4-diaminobenzene as a diamine and 3.6g (14.3 mmol) of bicyclo[3.3.0]-octane-tetracarboxylic dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at 20°C for 4 hours to carry out a polycondensation reaction, but 10 polymerization did not substantially proceed, and only an oligomer was formed. Further, heating was carried out, but no improvement in effects was observed.

#### COMPARATIVE EXAMPLE 3

5g (14.3 mmol) of hexadecyloxy-2,4-diaminobenzene as 15 a diamine and 4.3g (14.3 mmol) of 3,4-dicarboxy-1,2,3,4-tetrahydro-1-naphthalene succinic dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at 20°C for 4 hours to carry out a polycondensation reaction, but polymerization did not 20 substantially proceed, and only an oligomer was formed. Further, heating was carried out, but no improvement in effects was observed.

#### COMPARATIVE EXAMPLE 4

5g (14.3 mmol) of hexadecyloxy-2,4-diaminobenzene as 25 a diamine and 3.6g (14.3 mmol) of 3,5,6-tricarboxynorbornane-2:3,5:6 dianhydride were dissolved in 40g of N-methylpyrrolidone, followed by stirring at

20°C for 4 hours to carry out a polycondensation reaction, but polymerization did not substantially proceed, and only an oligomer was formed. Further, heating was carried out, but no improvement in effects  
5 was observed.

#### EXAMPLES 26 to 45

(Preparation of liquid crystal alignment films)

Then, a polyimide precursor or a polyimide solution obtained in one of Examples 6 to 25 was coated on a glass  
10 substrate and heat-treated at 180°C to form a polyimide coating film, whereupon the tilt angle and the uniformity in alignment of liquid crystal when used as a liquid crystal alignment film, were measured in accordance with the following methods.

15 Evaluation of the tilt angle: a polyimide precursor or a polyimide solution obtained in one of Examples 6 to 21 and Comparative Example 1 was diluted with N-methylpyrrolidone or  $\gamma$ -butyrolactone to obtain a solution having a resin concentration of 5%, which was  
20 spin-coated on a transparent electrode-mounted glass substrate at a rotational speed of 3500 rpm and heated at 80°C for 10 minutes and at 250°C for one hour to obtain a uniform polyimide coating film. After rubbing this coating film with a cloth, such substrates were assembled  
25 so that the rubbing directions were in parallel, with a spacer of 23  $\mu$ m interposed, and liquid crystal (ZLI-2003, manufactured by Merck Company) was injected to prepare a

cell having homeotropic or homogeneous alignment.

With respect to this cell, after heat treatment at 120°C for one hour, the uniformity of liquid crystal alignment under a polarization microscope was confirmed, 5 and the tilt angle was measured by a crystal rotation method or a magnetic field quantitative method. The results are shown in Table 2.

Table 2

Example No.	Polyimide (Example No.)	Diamine (Example No.)	Tilt angle (°)	Uniformity of alignment
26	6*	1	90	Uniform
27	7	1	90	Uniform
28	8	1	90	Uniform
29	9	1	90	Uniform
30	10*	2	6	Uniform
31	11	2	2	Uniform
32	12	2	3	Uniform
33	13	2	3	Uniform
34	14*	3	90	Uniform
35	15	3	90	Uniform
36	16	3	90	Uniform
37	17	3	90	Uniform
38	18*	4	90	Uniform
39	19	4	90	Uniform
40	20	4	90	Uniform
41	21	4	90	Uniform
42	22*	5	90	Uniform
43	23	5	90	Uniform
44	24	5	90	Uniform
45	25	5	90	Uniform
Comp. Ex. 1	1		90	Non- uniform

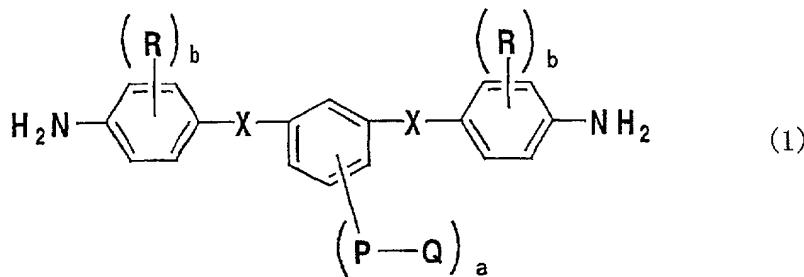
\*: The polyimide precursor solution was employed.

INDUSTRIAL APPLICABILITY

The diaminobenzene derivative of the present invention can easily be synthesized and irrespective of the structure of the acid dianhydride, it has a high reactivity for swift polymerization, whereby the corresponding polyimide having a high molecular weight can easily be obtained. Further, in the case of a polyimide for an alignment film for a liquid crystal display device, it is capable of aligning liquid crystal uniformly, whereby a desired tilt angle can easily be obtained.

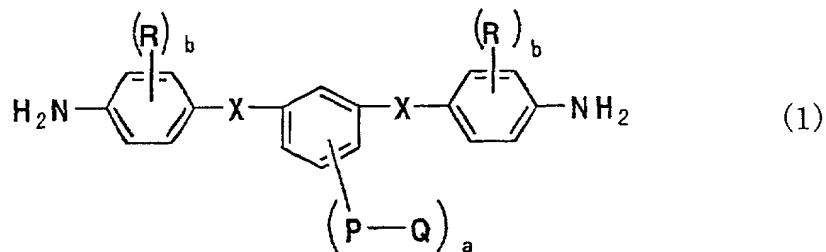
CLAIMS

1. A diaminobenzene derivative represented by the general formula (1):

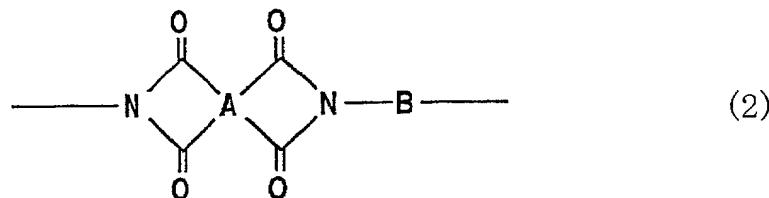


5 (wherein each of X and P which are independent of each other, is a single bond or a bivalent organic group selected from -O-, -COO-, -OCO-, -CONH- and -NHCO-, Q is a C<sub>1-22</sub> straight chain alkyl group or straight chain fluoroalkyl group, a is an integer of from 1 to 4 and 10 represents the number of substituents, R is a substituent selected from fluorine, a methyl group and a trifluoromethyl group, and b is an integer of from 0 to 4 and represents the number of substituents).

2. A polyimide obtained by reacting a diamine containing 15 at least 1 mol% of a diaminobenzene derivative represented by the general formula (1):



(wherein each of X and P which are independent of each other, is a single bond or a bivalent organic group selected from -O-, -COO-, -OCO-, -CONH- and -NHCO-, Q is a C<sub>1-22</sub> straight chain alkyl group or straight chain 5 fluoroalkyl group, a is an integer of from 1 to 4 and represents the number of substituents, R is a substituent selected from fluorine, a methyl group and a trifluoromethyl group, and b is an integer of from 0 to 4 and represents the number of substituents), with at least 10 one compound selected from a tetracarboxylic dianhydride and its derivatives, to obtain a polyimide precursor having a reduced viscosity of from 0.05 to 5.0 dl/g (in N-methylpyrrolidone at a temperature of 30°C, concentration: 0.5 g/dl) and ring-closing it, and having 15 a repeating unit represented by the general formula (2):

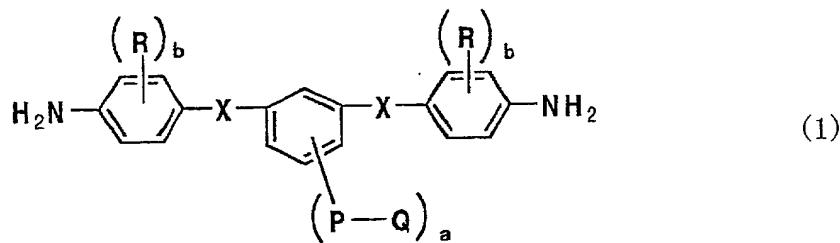


(wherein A is a tetravalent organic group constituting a 20 tetracarboxylic acid, and B is a bivalent organic group constituting a diamine).

3. The polyimide according to Claim 2, wherein the tetracarboxylic dianhydride is an alicyclic tetracarboxylic dianhydride.

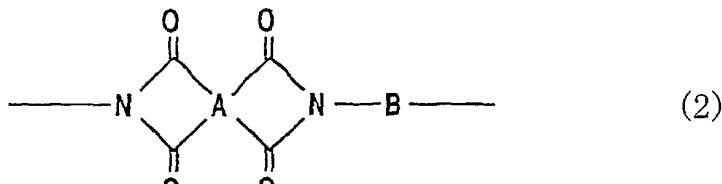
4. The polyimide according to Claim 3, wherein the alicyclic tetracarboxylic dianhydride is at least one tetracarboxylic dianhydride selected from 1,2,3,4-cyclobutane tetracarboxylic dianhydride, bicyclo[3,3,0]-5-octane tetracarboxylic dianhydride, 3,4-dicarboxy-1,2,3,4-tetrahydro-1-naphthalene succinic dianhydride and 3,5,6-tricarboxynorbornane-2:3,5:6 dianhydride.

5. A liquid crystal alignment film containing a polyimide obtained by reacting a diamine containing at least 1 mol% of a diaminobenzene derivative represented by the general formula (1):



(wherein each of X and P which are independent of each other, is a single bond or a bivalent organic group selected from -O-, -COO-, -OCO-, -CONH- and -NHCO-, Q is a C<sub>1-22</sub> straight chain alkyl group or straight chain fluoroalkyl group, a is an integer of from 1 to 4 and represents the number of substituents, R is a substituent selected from fluorine, a methyl group and a trifluoromethyl group, and b is an integer of from 0 to 4 and represents the number of substituents), with at least one compound selected from a tetracarboxylic dianhydride and its derivatives, to obtain a polyimide precursor

having a reduced viscosity of from 0.05 to 5.0 dl/g (in N-methylpyrrolidone at a temperature of 30°C, concentration: 0.5 g/dl) and ring-closing it, and having a repeating unit represented by the general formula (2):



(wherein A is a tetravalent organic group constituting a tetracarboxylic acid, and B is a bivalent organic group constituting a diamine).

6. The liquid crystal alignment film according to Claim 10 5, wherein the tetracarboxylic dianhydride is an alicyclic tetracarboxylic dianhydride.

7. The liquid crystal alignment film according to Claim 6, wherein the alicyclic tetracarboxylic dianhydride is at least one tetracarboxylic dianhydride selected from 15 1,2,3,4-cyclobutane tetracarboxylic dianhydride, bicyclo[3.3.0]-octane tetracarboxylic dianhydride, 3,4-dicarboxy-1,2,3,4-tetrahydro-1-naphthalene succinic dianhydride and 3,5,6-tricarboxynorbornane-2:3,5:6 dianhydride.

(in the formula (1), each of X and P which are independent of each other, is a single bond or a bivalent organic group selected from -O-, -COO-, -OCO-, -CONH- and -NHCO-, Q is a C<sub>1-22</sub> straight chain alkyl group or 5 straight chain fluoroalkyl group, a is an integer of from 1 to 4 and represents the number of substituents, R is a substituent selected from fluorine, a methyl group and a trifluoromethyl group, and b is an integer of from 0 to 4 and represents the number of substituents, and in the 10 formula (2), A is a tetravalent organic group constituting a tetracarboxylic acid, and B is a bivalent organic group constituting a diamine).

## Declaration and Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

## Japanese Language Declaration

## 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者（下記の名称が複数の場合）であると信じています。

\_\_\_\_\_

上記発明の明細書は、

- 本書に添付されています。
- \_\_\_\_月\_\_\_\_日に提出され、米国出願番号または特許協定条約国際出願番号を\_\_\_\_\_とし、  
(該当する場合)\_\_\_\_\_に訂正されました。

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

DIAMINOBENZENE DERIVATIVE, POLYIMIDE  
EMPLOYING IT, AND LIQUID CRYSTAL  
ALIGNMENT FILM

the specification of which

- is attached hereto.
- was filed on June 28, 2000  
as United States Application Number or  
PCT International Application Number  
PCT/JP00/04250 and was amended on  
\_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

**Japanese Language Declaration**  
(日本語宣言書)

私は、米国法典第35編119条 (a) - (d) 項又は365条 (b) 項に基づき下記の、米国以外の国の中なくとも一ヵ国を指定している特許協力条約365 (a) 項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

Prior Foreign Application(s)

外国での先行出願

11-185164

Japan

(Number)  
(番号)

(Country)  
(国名)

(Number)  
(番号)

(Country)  
(国名)

私は、第35編米国法典119条 (e) 項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条 (c) に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

PCT/JP00/04250

28/June/2000

(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

私は、私自信の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基づく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Claimed	
優先権主張	
<input checked="" type="checkbox"/>	<input type="checkbox"/>
Yes はい	No いいえ
<input type="checkbox"/>	<input type="checkbox"/>
Yes はい	No いいえ

30/June/1999

(Day/Month/Year Filed)  
(出願年月日)

(Day/Month/Year Filed)  
(出願年月日)

(Application No.)  
(出願番号)

(Filing Date)  
(出願日)

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

Pending

(Status: Patented, Pending, Abandoned)  
(現況: 特許許可済、係属中、放棄済)

(Status: Patented, Pending, Abandoned)  
(現況: 特許許可済、係属中、放棄済)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## Japanese Language Declaration

(日本語宣言書)

委任状：私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。  
(弁護士、または代理人の指名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: (list name and registration number)



022850

書類送付先

Send Correspondence to:



022850

直接電話連絡先：（名前及び電話番号）

Direct Telephone Calls to: (name and telephone number)

(703) 413-3000

単独発明者または第一の共同発明者の氏名		Full name of sole or first joint inventor <i>Kazuyoshi Hosaka</i>	
発明者の署名	日付	Inventor's signature <i>Kazuyoshi Hosaka</i>	Date <i>Nov. 26, 2001</i>
住所		Residence <i>Chiba, Japan</i>	<i>SPX</i>
国籍		Citizenship <i>Japanese</i>	
郵便の宛先		Post Office Address <i>c/o Nissan Chemical Industries, Ltd. Central Research Institute, 722-1, Tsuboi-cho, Funabashi-shi, CHIBA 274-8507 JAPAN</i>	
第二の共同発明者の氏名		Full name of second joint inventor, if any <i>Hideyuki Nawata</i>	
第二の共同発明者の署名	日付	Second joint Inventor's signature <i>Hideyuki Nawata</i>	Date <i>Nov. 22, 2001</i>
住所		Residence <i>Chiba, Japan</i>	<i>SPX</i>
国籍		Citizenship <i>Japanese</i>	
郵便の宛先		Post Office Address <i>c/o Nissan Chemical Industries, Ltd. Central Research Institute, 722-1, Tsuboi-cho, Funabashi-shi, CHIBA 274-8507 JAPAN</i>	

(第三以降の共同発明者についても同様に記載し、署名すること)

(Supply similar information and signature for third and subsequent joint inventors.)

## Japanese Language Declaration

(日本語宣言書)

第三の共同発明者の氏名	Full name of third joint inventor, if any <u>Takayasu Nihira</u>		
第三の共同発明者の署名	日付	Third joint Inventor's signature <u>Takayasu Nihira</u>	Date <u>Nov. 21. 2001</u>
住所	Residence <u>Chiba, Japan</u>		
国籍	Citizenship <u>Japanese</u>		
郵便の宛先	Post Office Address c/o Nissan Chemical Industries, Ltd. Central Research Institute, 722-1, Tsuboi-cho, Funabashi-shi, CHIBA 274-8507 JAPAN		

第四の共同発明者の氏名	Full name of fourth joint inventor, if any <u>Hideyuki Isozaki</u>		
第四の共同発明者の署名	日付	Fourth joint Inventor's signature <u>Hideyuki Isozaki</u>	Date <u>Nov. 21. 2001</u>
住所	Residence <u>Chiba, Japan</u>		
国籍	Citizenship <u>Japanese</u>		
郵便の宛先	Post Office Address c/o Nissan Chemical Industries, Ltd. Central Research Institute, 722-1, Tsuboi-cho, Funabashi-shi, CHIBA 274-8507 JAPAN		

第五の共同発明者の氏名	Full name of fifth joint inventor, if any <u>Hideyuki Endou</u>		
第五の共同発明者の署名	日付	Fifth joint Inventor's signature <u>Hideyuki Endou</u>	Date <u>Nov. 21. 2001</u>
住所	Residence <u>Chiba, Japan</u>		
国籍	Citizenship <u>Japanese</u>		
郵便の宛先	Post Office Address c/o Nissan Chemical Industries, Ltd. Central Research Institute, 722-1, Tsuboi-cho, Funabashi-shi, CHIBA 274-8507 JAPAN		

第六の共同発明者の氏名	Full name of sixth joint inventor, if any <u>Hiroyoshi Fukuro</u>		
第六の共同発明者の署名	日付	Sixth joint Inventor's signature <u>Hiroyoshi Fukuro</u>	Date <u>Nov. 21. 2001</u>
住所	Residence <u>Chiba, Japan</u>		
国籍	Citizenship <u>Japanese</u>		
郵便の宛先	Post Office Address c/o Nissan Chemical Industries, Ltd. Central Research Institute, 722-1, Tsuboi-cho, Funabashi-shi, CHIBA 274-8507 JAPAN		

(第六またはそれ以降の共同発明者に対しても同様な情報および署名を提供すること。)

(Supply similar information and signature for third and subsequent joint inventors.)